Optimizing Phosphorus Supplementation of Grazing Beef Cattle

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Phosphorus management in crop, poultry and livestock production systems continues to be an important topic. The draft Total Maximum Daily Load (TMDL) proposal for the Chesapeake Bay provides aggressive reduction targets for nitrogen, phosphorus and sediment. These TMDL targets refer to the maximum amount of a pollutant that a water body can receive and still meet water quality standards. Phosphorus runoff in surface waters is a contributing factor to algal blooms and aquatic plant growth which can reduce water oxygen levels and at times have detrimental effects on fish and other aquatic organisms. Agricultural runoff from crop fields and manure is a contributing factor to phosphorus levels in surface waters. As such, land application of phosphorus fertilizer and manure is monitored. Concentrated animal feeding operations (CAFOs) are also monitored because of the amount of manure produced. The majority of CAFOs in the Chesapeake Bay watershed are dairy and poultry operations. However, the feces of grazing beef cattle can also contribute to phosphorus runoff. Opportunity currently exists within grazing beef cow/calf production systems to limit phosphorus inputs and thus increase economic benefits while minimizing environmental impacts.

Phosphorus (P) is an important component of a variety of metabolic and cell regulatory processes, as it is essential for energy metabolism and the transfer of genetic information. Phosphorus can be recirculated via saliva. Phosphorus secreted in saliva functions in two primary ways: 1) as a buffer to prevent large fluctuations in pH from organic acid production, and 2) as a source of P for rumen and gastrointestinal microbes. Based upon its importance, P acts as a dynamic nutrient within the animal, and levels are maintained within the animal primarily through fluctuations in endogenous fecal P losses bone p reserves, as well as secretion through both saliva and urine. In cattle, P is primarily excreted through the feces. The relationship between dietary P and fecal P is linear, meaning that as dietary P increases, more P is excreted via the feces. A significant portion of the fecal P is in the form of inorganic P (P_i) which is water soluble. Over time, P_i is capable of binding to soil particles and becoming less soluble. Until this occurs, however, P_i can contribute to increased P runoff during rain events.

In the past, phosphorus has often been over-supplemented due to its once cheap cost and at the advice of many nutritionists and veterinarians due to concerns that a deficiency in P could negatively impact reproduction. Further examination of those trials has revealed that most were conducted in arid and semi-arid range areas with very different soil types, forage species and rainfall than those of the eastern U.S. However, more emphasis should be placed on meeting, without exceeding, P requirements to be both economically and environmentally responsible.

Beef cattle P requirements

Historically, beef cattle P requirements have been expressed as a percent P of the animal's daily dry matter intake. Expressing P requirements in this way has been well received and easily incorporated from a nutritional formulation standpoint as P and dry matter intakes are directly proportional, allowing it to be used consistently for cattle of varying weights. More recently, P requirements have been expressed as the amount of available (absorbed) P required by the animal to meet the needs of various physiological functions, including maintenance, growth and lactation. The major factors affecting beef cow P requirements include stage of production, fetal growth and milk production (tables 1 and 2). A true P absorption of 68 percent was used to then express animal P requirements in terms of dietary concentration. Table 3 contains the P requirement of a growing beef steer across different weights and performance levels. As expected, young, lightweight and fast-growing cattle have greater P requirements when compared to older, heavier weight cattle that are growing less rapidly, which is primarily attributable to differences in the rate of tissue and skeletal growth.

Table 1.	Phosphorus requirements of beef cattle, % DM			
	Months since calving	Peak milk production lbs./d		
1200 lb cow		10	20	30
	1	.17	.19	.22
	2	.17	.21	.23
	3	.16	.19	.21
	4	.15	.18	.20
	5	.15	.17	.18
	6	.14	.15	.17
	dry	.13	.13	.13
Last trimester of gestation		.16	.16	.16

Table 2.	Phosphorus requirements of beef cattle, lbs./d			
	Months since calving	Peak milk production lbs./d		
1200 lb cow		10	20	30
	1	.042	.055	.066
	2	.046	.060	.073
	3	.044	.057	.068
	4	.042	.051	.062
	5	.040	.046	.055
	6	.037	.042	.049
	dry	.031	.031	.031
Last trimester of gestation		.042	.042	.042

Table 3. Nutrient requirements for growing medium frame steers.

Body Weight lb	Avg. Daily Gain lb	Dry Matter Intake lbs./d	P %	P lbs/d	Body Weight lb	Avg. Daily Gain lb	Dry Matter Intake lbs./d	P %	P lbs/d
300	0.5	7.8	0.20	0.013	600	0.5	13.2	0.18	0.024
	1.0	8.4	0.24	0.019		1.0	14.1	0.19	0.027
	1.5	8.7	0.28	0.025		1.5	14.7	0.21	0.031
	2.0	8.9	0.32	0.031		2.0	15.0	0.22	0.033
	2.5	8.9	0.37	0.037		2.5	14.9	0.24	0.036
	3.0	8.0	0.47	0.043		3.0	13.5	0.29	0.039
400	0.5	9.7	0.18	0.015	700	0.5	14.8	0.18	0.027
	1.0	10.4	0.21	0.021		1.0	15.8	0.18	0.028
	1.5	10.8	0.25	0.026		1.5	16.5	0.20	0.033
	2.0	11.0	0.26	0.032		2.0	16.8	0.21	0.035
	2.5	11.0	0.30	0.037		2.5	16.7	0.22	0.037
	3.0	10.0	0.37	0.043		3.0	15.2	0.26	0.040
500	0.5	11.5	0.17	0.020	800	0.5	16.4	0.17	0.028
	1.0	12.3	0.20	0.025		1.0	17.5	0.19	0.033
	1.5	12.8	0.22	0.028		1.5	18.2	0.19	0.035
	2.0	13.1	0.24	0.031		2.0	18.6	0.20	0.037
	2.5	13.0	0.27	0.035		2.5	18.5	0.21	0.039
	3.0	11.8	0.32	0.038		3.0	16.8	0.25	0.042

A combination of the P content of feedstuffs and the animal's requirement determines if P supplementation is necessary. In many situations, the feedstuff consists of the grazed or harvested forage to which the cattle have access. Determining the P content of forages through a feed analysis is the first step to developing a supplementation strategy. Feeding P at levels that exceed cattle requirements will not substantially increase P retention or improve performance, but will increase the amount of excess P that is excreted primarily in the feces as P_i.

Forage Phosphorus

Forage P content varies between plant species and is influenced by stage of maturity and rainfall, as well as the pH and available phosphorus of the soil. Recent pasture soil samples collected in 13 Virginia Chesapeake Bay watershed counties had an average available P level of 67 lbs/acre which is in the lower portion of the high level. Only 12% of the soil samples fell into low level category (Figure1). In most of the sampled pastures, forage P content would not be limited by available soil P. The other factors that could contribute to lower than expected forage P levels would be forage maturity or drought conditions.

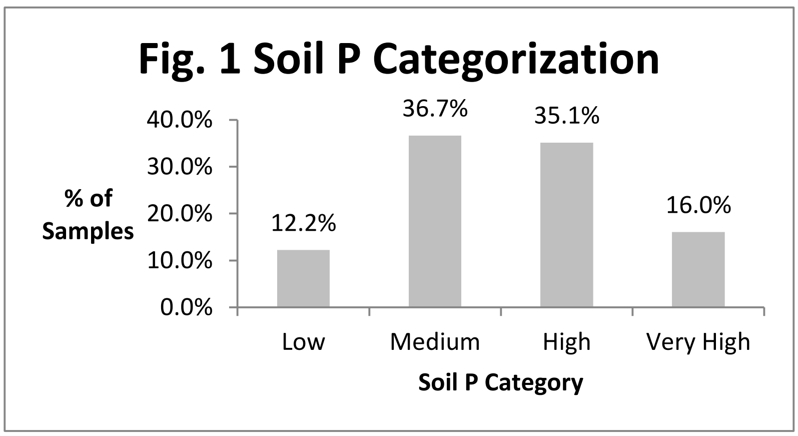
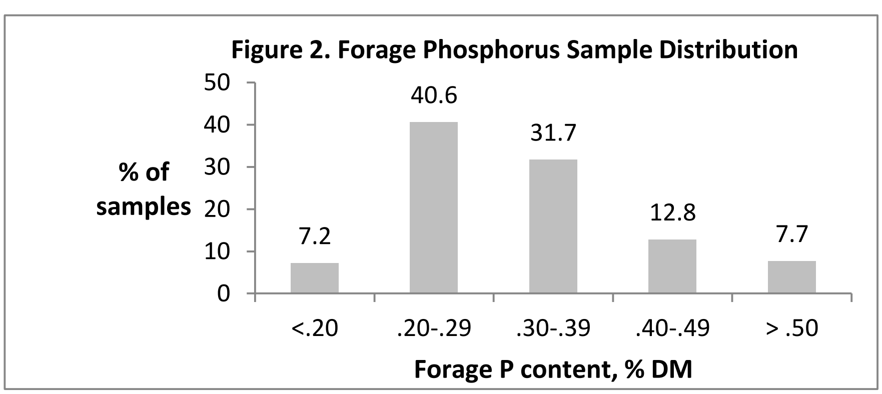
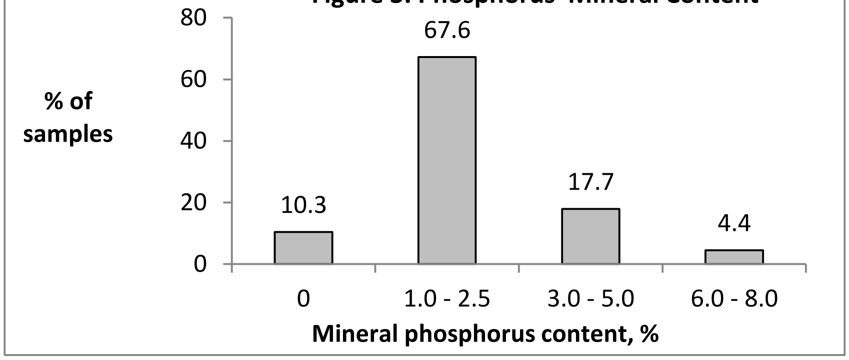


Figure 2 displays the distribution of forage P content of forage samples from the fields where the soil samples were collected. Over 95 % of the forage sample P content equals or exceeds the requirement of a lactating cow with average milk production. More than 56 % of the samples exceeded 0.30 % P which is above all cow production requirements and is sufficient for stocker calves gaining 2.0 lb/d. In general, little P supplementation was warranted on the sampled farms. Low level P supplementation could be required depending on the age and productivity of the animals grazing pastures with forage P levels below 0.20 %.



Phosphorus is supplemented to grazing beef cattle most often in the form of a free-choice mineral containing a desired level of P. Commercially available minerals are available that contain a wide range of P content. Usually in eastern U.S., these mineral supplements range from 0 to 8 % P. Phosphorus is the most expensive macro mineral and P content is one of the major factors that impacts the cost of the mineral supplement. Farms included in the soil and forage survey provided free-choice mineral supplements that ranged from 0 to 8 % P (Figure 3). Seventy eight percent of the mineral supplements offered to cows consisted of less than 3.0% P, with two thirds of the farms using minerals which contained 1.0 to 2.5% P.

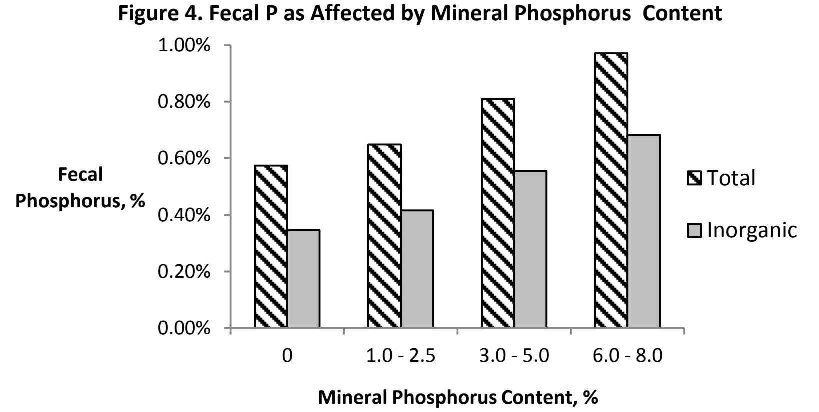
Figure 3. Phosphorus Mineral Content



Phosphorus Excretion

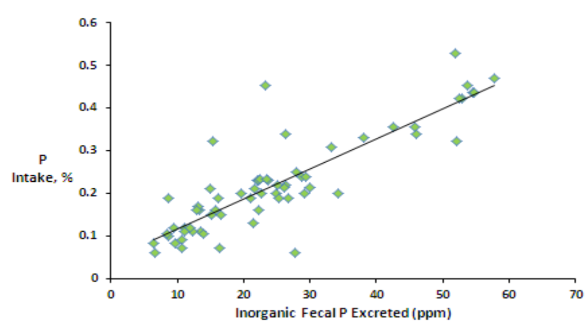
A variety of forms of P exist in feces, all of which have a varying degree of availability to plants. Total P (P_t) is comprised of inorganic and organic forms of P. Inorganic P easily dissolves in water and is often referred to as water soluble or water extractable phosphorus. This characteristic makes it more available to plants as well as at a greater risk for runoff. High phosphorus diets fed to cattle leads to a greater percentage of fecal P_i. Reports have indicated that confined feeder cattle and feedlot cattle manure contained 47.1% and 48.3% Pi, respectively, while reports have indicated that the feces of dairy cattle have a higher average proportion at 63.2%. The author that reported these values found the portions of P in collected feces to be considerably higher than values historically reported in the literature. Inorganic P is the most critical component of P_t in manure, as its beneficial effect on plant growth as a fertilizer is dependent on it. Decreasing the water soluble portion of P_t is critical to decreasing the risk of pollution in waterways. Figure 4 shows the relationship between mineral P content and level of fecal P excretion on the sampled farms. As P content of the free-choice mineral supplement increased, both P_t and P_i levels increased.

Figure 4. Fecal P as Affected by Mineral Phosphorus Content



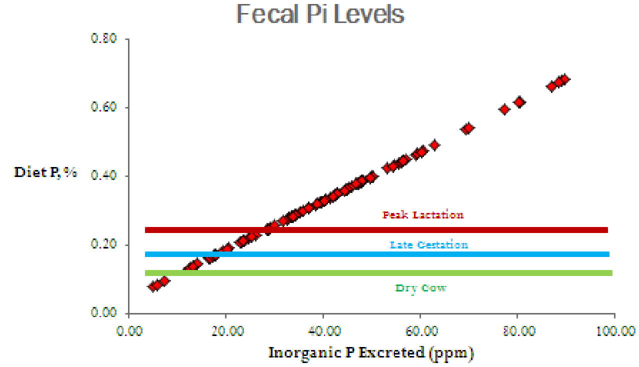
Two feeding trials with growing beef steers were conducted at Virginia Tech to measure the effect of increasing P supplementation on the excretion of P_t and P_i. One trial used a mineral form of P to increase dietary levels, while the second trial used corn gluten feed (1.0 % P) as an organic feed source of P. Fecal collection bags were used to facilitate total daily fecal collection. The impact of varying levels of dietary P intake on P_i excretion was similar for both trials and the data has been combined in Figure 5. Roughly 75% of the variation in P_i excretion is accounted for by the amount of dietary P that was consumed by the steers regardless of form.

Figure 5. Level % P of Intake by Fecal Inorganic P



This is a particularly valuable relationship because it also allows for the estimation of dietary P levels based on the concentration of P_i in the feces. Fecal P_i data from the field study samples can be used to estimate the dietary P consumption of grazing cows on the sampled farms. Figure 6 includes this estimation with key target nutritional requirements overlaid. Based on Fecal P_i concentration it is estimated that over two-thirds of the cattle were consuming P in excess of the needs of a lactating cow. In these situations, a mineral containing no P should be utilized.

Figure 6. Predicted P intake from Field Sample Fecal Pi Levels



Steps to assess your herd's P status

Three basic questions need to be addressed to determine the P status of beef cattle and decide if and how much P supplementation is warranted.

1) Soil samples and forage samples are the most logical place to start in getting a handle on your P status. Soil P levels provide a foundation of the amount of P that is available for plant growth. Soil P content at the medium level (12-35 lbs/ac) will not require additional P and should not limit forage P content. Be mindful that hay production will remove P and hay fields could need additional P to stay at the medium level.

2) Forage P levels are the best gauge in determining which level of P to include in a free-choice mineral. You will need a minimum of fresh forage and a hay sample to represent both grazed and stored forage. Lab results can be compared to the P requirements in Tables 1-3 to determine if P supplementation is needed. If you are feeding a supplement during the winter, the P content of the supplement needs to be considered in conjunction with the hay.

3) A fecal analysis for P_t and P_i will allow for the best status estimate of P status for the animal because it is affected by the forage P content, mineral P content and any supplemental feed P. Laboratory results can be compared to the values in Figure 6 to predict total diet P content.

In conclusion, P status of our waterways is affected by agricultural and non-agricultural activities in the watershed. Overfeeding P to beef cattle simply leads to greater fecal P excretion; much of which is in the higher risk, P_i form. Through a combination of monitoring forage P and selecting the correct mineral, fecal P excretion can be minimized at both an environmental and economic benefit.

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